INDOOR AIR QUALITY ASSESSMENT

Berkshire Athenaeum
1 Wendell Avenue
Pittsfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

In response to a request from Ronald Latham, Library Director, an indoor air quality assessment was done at the Berkshire Athenaeum (BA), 1 Wendell Avenue, Pittsfield, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). The assessment was conducted to identify the source of odors reported by both patrons and employees on the ground floor area as well as general indoor air quality conditions within the building.

On June 28, 2002, Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), made a visit to the BA. The BA is a three-story structure constructed in 1974, on a slope with the western section of the ground floor located below grade. The main floor contains a large open atrium that extends three stories to the upper roof (see Picture 1). Above the main floor is a large balcony that contains library stacks and walkways to administrative offices and meeting rooms (see Map 1). The main floor contains a number of separate rooms and offices (see Map 2). The two upper floors are referred to in the remainder of this report as the "upper floors"). The lower floor contains the children's library, bookmobile stacks, mechanical rooms, maintenance office and auditorium (see Map 3). A garage is located below the lower floor on the south wall of the building. Windows open in a number of areas in the building. The floor is carpeted, with the exception of the auditorium.

The building was renovated in 1997. Various unit ventilators were replaced throughout the building. In addition, the ground floor was reconfigured, which removed some interior walls and a sink cabinet.

The building was previously evaluated by the Massachusetts Department of Labor and Industries (MDLI), Division of Occupational Hygiene (DOH), now the Massachusetts Department of Labor and Workforce Development, Division of Occupational Safety (MDLWD). The MDLI report made the following recommendations:

1. Repair the roof;
2. acquire more custodial staff;
3. follow DOH guidelines for ventilation and water damaged materials;
4. repair smoker's lounge ventilation;
5. repair the general ventilation system;
6. balance, clean and operate the ventilation system for the children's library (MDLI, 1993).

The roof was replaced in 1997. No smoker's lounge currently exists in the building. The ceiling and interior was free of water damage.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The BA has a daily employee population of approximately 15-20 and an estimated 900 to 1,000 other individuals who visit on a daily basis. The tests were taken under normal operating conditions. Test results appear in Tables 1-2. Air sampling results are listed in the tables by location that the air sample was taken.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were below 800 parts per million parts of air [ppm] in all areas surveyed throughout the BA. These carbon dioxide levels are indicative of an adequate fresh air supply.

The ventilation system is divided into two sections: the upper floors and the lower floor. The upper floors of the BA are supplied with fresh air by a combination of air handling units (AHUs) and unit ventilators (univents) (see Picture 2). The majority of fresh air is distributed to offices and other enclosed rooms by ceiling mounted fresh air diffusers connected to each AHU via ductwork. In several areas no air movement was detected from air diffusers, indicating AHUs were deactivated. Univents are located along exterior walls. Fresh air appears to be drawn by each univent through a small lover located in the rear of its cabinet (see Picture 3). Each louver is set by hand to either a closed or open position (see Picture 4). Due to the size of the opening and installation, it appears that draw of fresh air by these univents is minimal. In the closed position each univent performs as a fan coil unit (FCU), which functions to solely heat or chill air without introducing outdoor air. A number of univents/FCUs were deactivated throughout the building.

The atrium also has a cabinet mounted blower that heats and chills air as needed (see Picture 1). It was unclear whether this system provides fresh air. The system was operating during the assessment.

Exhaust ventilation is provided by a number of rooftop units (see Picture 5). Exhaust air appears to exit the atrium from ceiling mounted grills (see Picture 6). An examination of the roof found fifteen of eighteen exhaust fans deactivated. Without exhaust ventilation, normally occurring environmental pollutants (e.g., waste heat from electronic equipment such as computers, microfilm viewers, fluorescent lights, etc.) can build up and lead to indoor air quality and comfort complaints.

The lower floor is supplied with fresh air from an AHU located in a below grade mechanical room. Fresh air is drawn through a subterranean pit, to the AHU, which is then distributed to the children's library by wall and ceiling mounted fresh air diffusers via ductwork. Air is returned to the AHU by a duct located in the ground floor slab (see Blueprint 1). As with the upper floors, univents/FCUs are installed along exterior walls to provide heated or chilled air identical to upper floor units.

In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air. The date of the last servicing and balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings were within the BEHA recommended range for comfort, with the exception of the Allen room, local history vault/area, Melville room and microfilm room (see Tables). The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Please note that areas above the BEHA temperature comfort range did not have functioning exhaust ventilation.

The relative humidity measured in the building ranged from 40 to 52 percent, which was within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Wall-mounted humidification units were installed throughout the BA during its construction (see Picture 7). A humidification system was also installed within the supply ductwork of the lower floor AHU. Mr. Latham reported that the wall-mounted humidifiers are not used due to excessive noise generation. One unit was activated, which produced a loud motor noise. Humidification equipment, if not maintained, can be a source of moisture and/or microbial growth. The interior of the ductwork connected to the humidification system could not be examined during the assessment. If repairs are not made to the humidification system to restore its function, it is advised to permanently decommission and possibly remove the system from the ventilation ductwork.

Various forms of debris [leaves (see Picture 8), old fiberglass insulation (see Picture 9), etc.] were noted in direct contact with the rubber membrane roof. In one instance, plants had taken root in the debris and were growing on the roof membrane (see Picture 10). Debris can hold water in contact with the roof, which may cause damage resulting in leaks from freezing and thawing during cold weather.

Several areas had a number of plants. Plant soil and drip pans can serve as source of mold growth. A number of these plants did not have drip pans. The plant in Picture 11 appears to be chronically over-watered. The desk that this plant rests on is water damaged. The lack of drip pans and/or over-watering can lead to water pooling and mold growth on porous materials (e.g. carpeting and wood). Plants should be properly maintained and be equipped with drip pans. Plants should also be located away from the air stream of mechanical ventilation to prevent aerosolization of dirt, pollen or mold.

A number of other sources of mold colonization exist in other areas within the building. Univents/FCUs provide both heating and air-conditioning. Each unit has a drip pan to collect and drain condensation from cooling coils. The manufacturer of the units installed a plastic liner to protect the drip pans from water damage. Each coil examined was caked with dirt and other debris, which can serve as a growth medium for mold when these units are activated. Several employees reported that mold odor emanates from the units when activated, which suggests that univents are not routinely cleaned.

As discussed, the fresh air intake for the lower floor is located in a subterranean pit below the north wall (see Picture 12). Subterranean pits tend to be prone to collection of moisture from rainwater and debris. If materials lining the floor of the pits are saturated with water, mold spores, water vapor and associated odors can be entrained into the AHU.

Other Concerns

Upon entering the BA's lower floor from outdoors, Mr. Feeney detected a slight musty odor near the front desk of the children's library. There seem to be four possible sources of this odor.

1. The most likely source appears to be drains located in the lower floor's restrooms or mechanical room. An examination of the floor drain in the men's room found the trap to be dry. Drains are usually designed with traps in order to prevent sewer odors/gases from penetrating into occupied spaces. When water enters a drain, the trap fills and forms a watertight seal. Without a periodic input of water

(e.g., every other day), traps can dry, which breaks the watertight seal. Without traps wet, odors can travel up the drain and enter the occupied space. Under ordinary circumstances, the restroom exhaust vent will draw air from the drain to the wall-mounted grille to the roof motor. The restroom exhaust vents were deactivated, therefore no removal of malodorous air was evident in the restroom. The return air vent for the lower floor in the children's library is located near a stairwell. Without operating restroom exhaust vents, the lower floor return vent can draw odors from the restrooms through the doorframe, towards the children's library front desk. The areas examined above correspond to areas of strongest odor complaints diagramed on a floor plan provided by Mr. Latham.

2. Another possible source of odor is the condensation drain that services the AHU providing fresh air to the children's library. The ventilation system for the lower floor is designed with a second fan (the second fan) to distribute air from and a fan within the AHU that draws fresh air and distributes it to the lower floor through a wall-mounted fresh air diffuser. In order to operate as designed, both fans must operate simultaneously. The fan in the AHU was deactivated (see Picture 13). The airflow through this ductwork appears to be provided by a unit separate from this AHU. This AHU is equipped to provide air-conditioning during warm months. AHUs that provide air-conditioning require the installation of condensation drains to prevent water build up inside the casing and ductwork. The condensation drains for these units terminate above a floor drain that is connected to the building drainage system (see Picture 14). Without the AHU fan running, the operation of the second fan depressurizes the AHU cabinet, which results in air being drawn to the cabinet via the condensation drain. If the

trap for this condensation drain is dry, the operation of the separate unit can then draw air and odors from the drain system and distribute them into occupied spaces on the lower floor. If the AHU fan is reactivated, the section of the cabinet where the condensation drain exists will become pressurized. Once pressurized, air is forced out of the condensation drainpipe preventing the entrainment of odors from the drain system by the ventilation system.

3. A third possible source of drain odor may exist in the basement. Mr. Latham reported that the lower floor was reconfigured, resulting in the removal of a sink. A pathway for odors may exist if the drain for this system was not rendered airtight. The most likely pathway would be a seam within the interior wall where the drain existed. Operation of the lower level return vent can draw odors towards the front desk.
4. A strong musty odor was denoted in the custodian's room from wet mops. Mop buckets containing standing water were also observed. Both standing water and wet mops can serve as mediums for mold growth. Mop buckets should be emptied and dried after use. Mop heads should be dried as soon as practicable following use to prevent mold growth and associated odors.

In each of these cases, musty odors would be the result of airflow over or from materials with microbial contamination. Restoration of drainpipe trap integrity or disposal of contaminated materials should occur to eliminate odors.

The BA has numerous restrooms located throughout the building. Restrooms with exhaust vents had little air movement, indicating that either motors to these vents are not operational or they are deactivated. Ventilation in restrooms is necessary to prevent moisture and odors from migrating into adjacent hallways and offices.

Air filters in univents/FCUs consist of ill-fitting metal screens that provide minimal filtration of respirable dust. AHUs examined were equipped with air filters that did not fit flush with their racks and also provided minimal filtration of respirable dust. Filters should be one piece that fit flush with the filter rack. If two filters are to be used, the filter rack must have the appropriate equipment to make each filter fit flush in the rack. Air drawn into the AHU will bypass filters through spaces between filters and racks. This can result in dust, dirt and other debris being distributed by the ventilation system. AHU filters are designed to strain particulates from airflow. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by increased resistance (called pressure drop). Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Conclusions/Recommendations

In view of these findings at the time of the visit, the following conclusions and recommendations are made:

1. Ensure water is poured into the lower floor restrooms and AHU floor drains every other day to maintain the integrity of the traps.

2. Repair the fan motor for the lower floor AHU and operate to pressurize the AHU cabinet to prevent odor entrainment via the condensation drain.
3. Repair/activate exhaust vents on roof. Operate exhaust ventilation during working hours.
4. Replace mops heads. Periodically launder mops in a timeframe consistent with manufacturer's recommendations and/or frequency of use. Dry mops outside when practicable.
5. Clean accumulated debris from floor of subterranean fresh air intake pit and roof periodically.
6. Operate restroom local exhaust ventilation during work hours. Repair motors as needed.
7. Contact the manufacturer to identify the proper procedure to disinfect univent drain pans.
8. Examine the feasibility of increasing the efficiency of AHU and univents/FCUs. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
9. Obtain spacers to render air filters flush within their racks to prevent air by-pass.
10. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when relative humidity is low. An increase in filter efficiency in the HVAC system may also be advisable. Drinking water during the day can help

ease some symptoms associated with a dry environment (throat and sinus irritations).

11. Move excessive numbers of plants from windows. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.

The following **long-term** measures should be considered.

1. A ventilation engineer should be consulted to resolve air supply/exhaust ventilation issues building-wide.
2. If filling drain traps with water; operating restroom exhaust vents; repairing and operating the lower floor AHU fan motor; and frequent changing or laundering of mops does not prevent further odors, consideration should be given to opening interior walls to located the abandoned drain.
3. If operation is not restored, consider removing the humidification equipment from the AHU ductwork.

References

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1.

MDLI. 1993. Massachusetts Department of Labor and Industries, Department of Occupational Hygiene. DOH Field Report, Berkshire Athenaeum, File No. 925-0169. Dated April 2, 1992.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. Mid Atlantic Environmental Hygiene Resource Center, Philadelphia, PA.

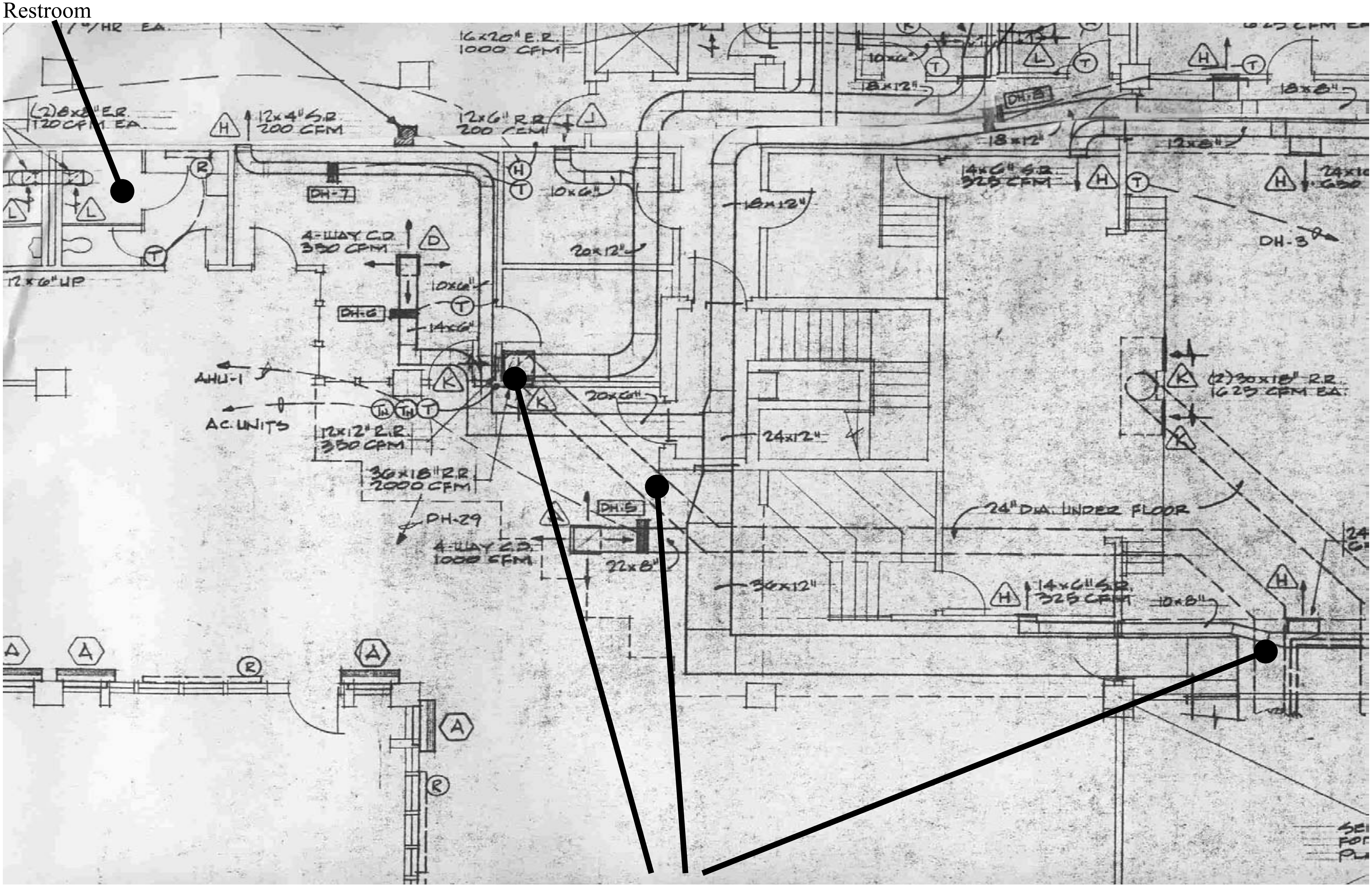
OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R. 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

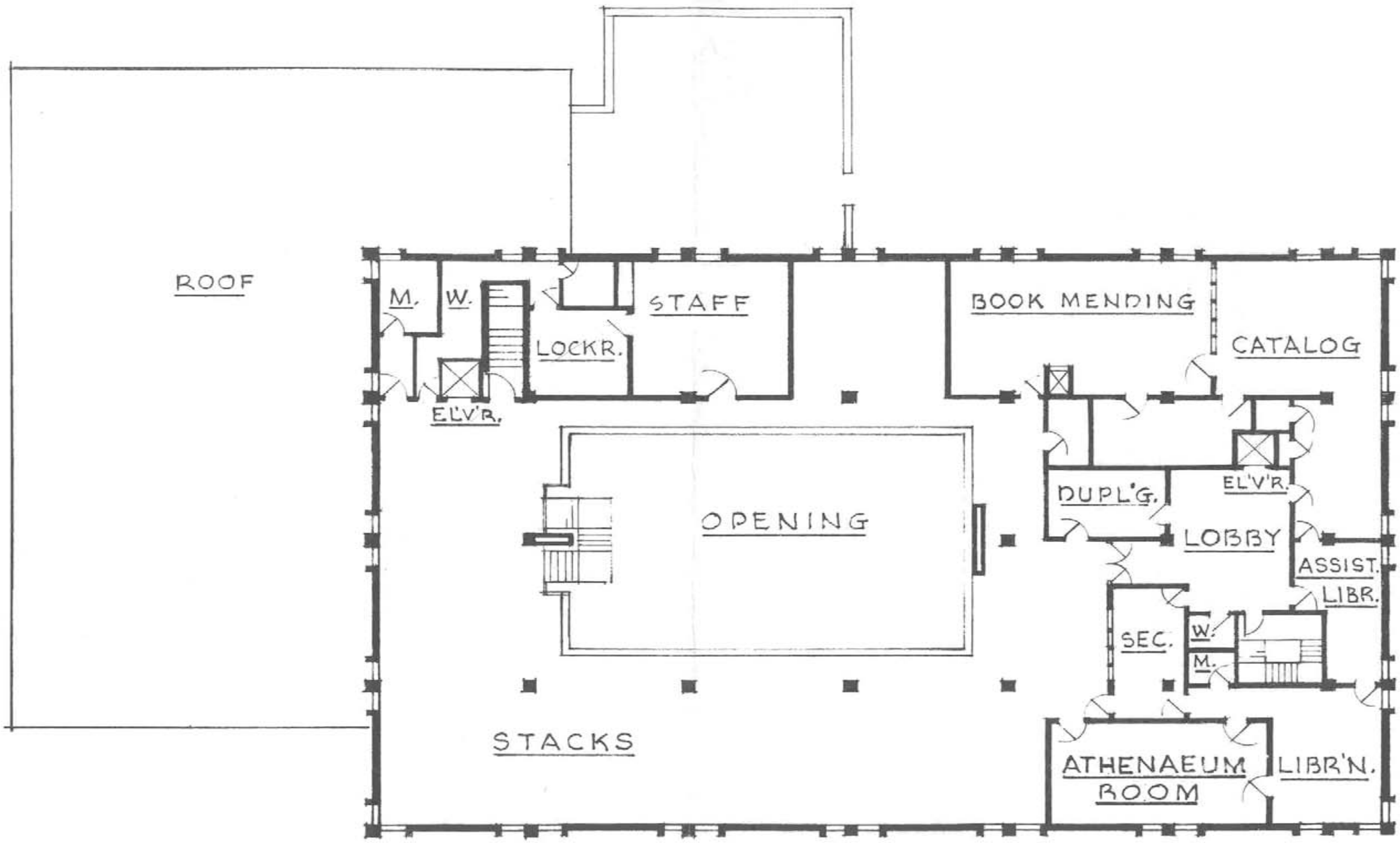
Thornburg, D. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Blueprint 1

Slab Installed Exhaust Vent Duct in Lower Floor, Note Restroom Location vis-à-vis exhaust vent

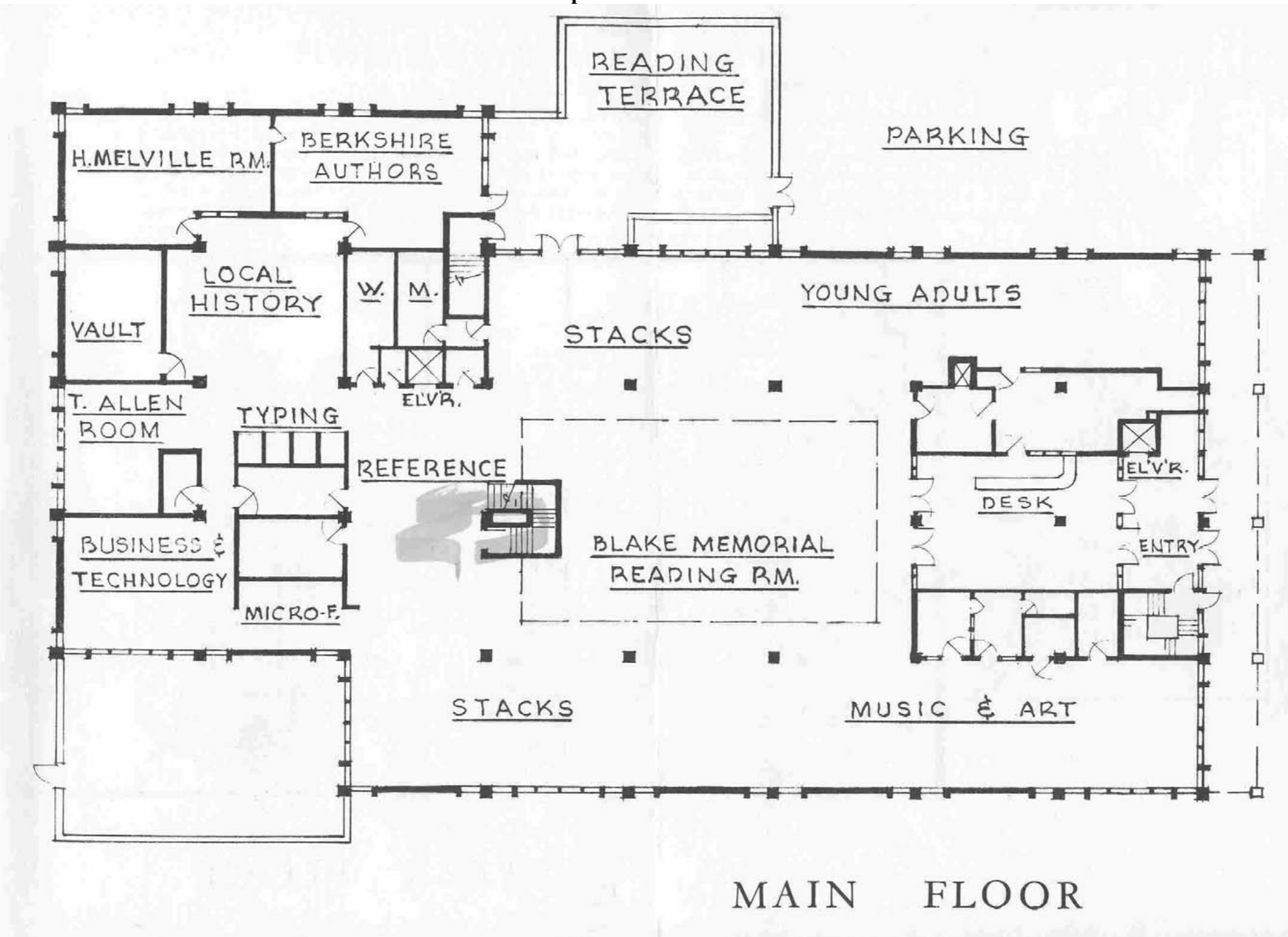


Map 1

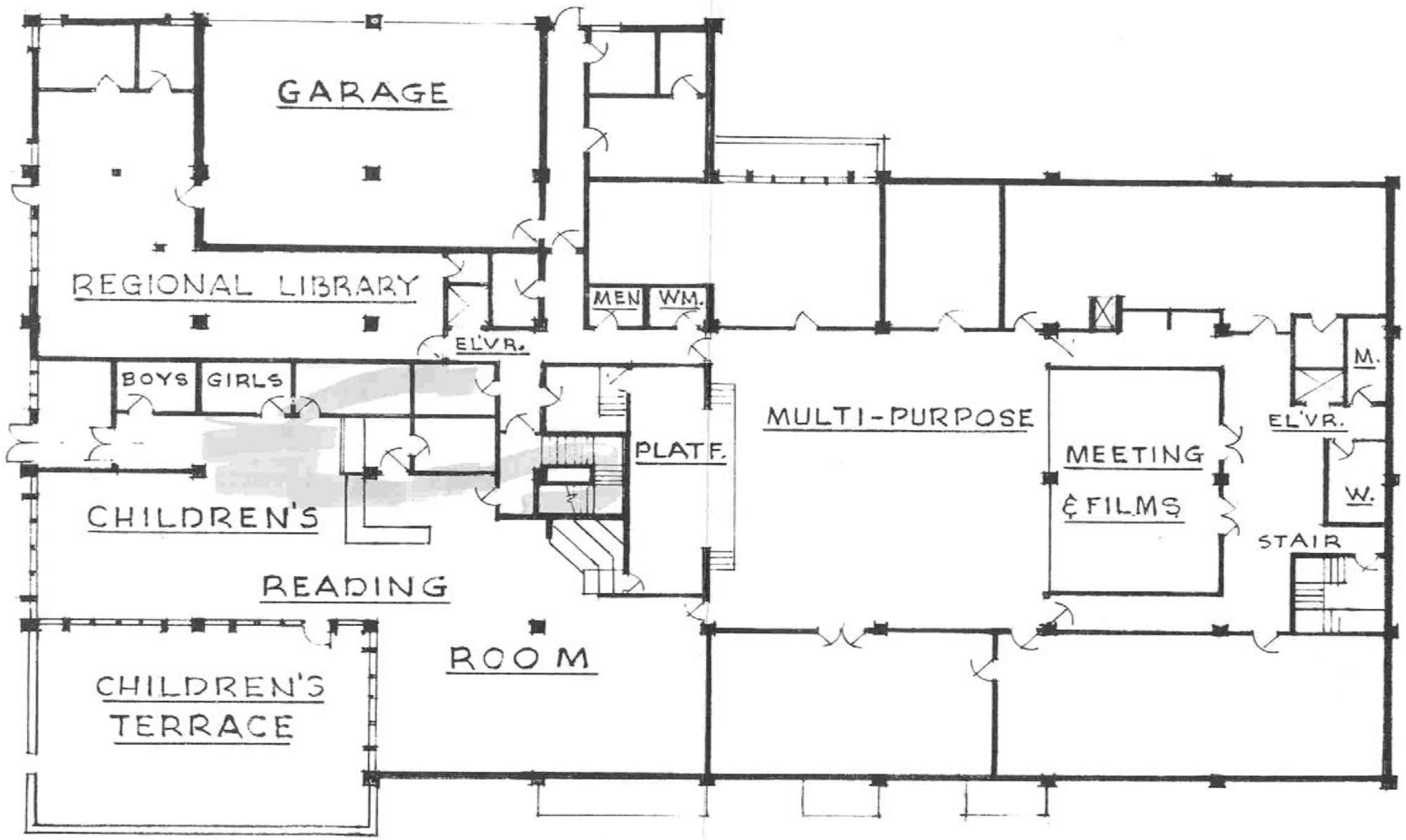


UPPER FLOOR

Map 2
Odor Reported in Darkened Area



Map 3
Odor Reported in Darkened Area



LOWER FLOOR

Picture 1

Air Diffuser In Cabinet

The Central Atrium

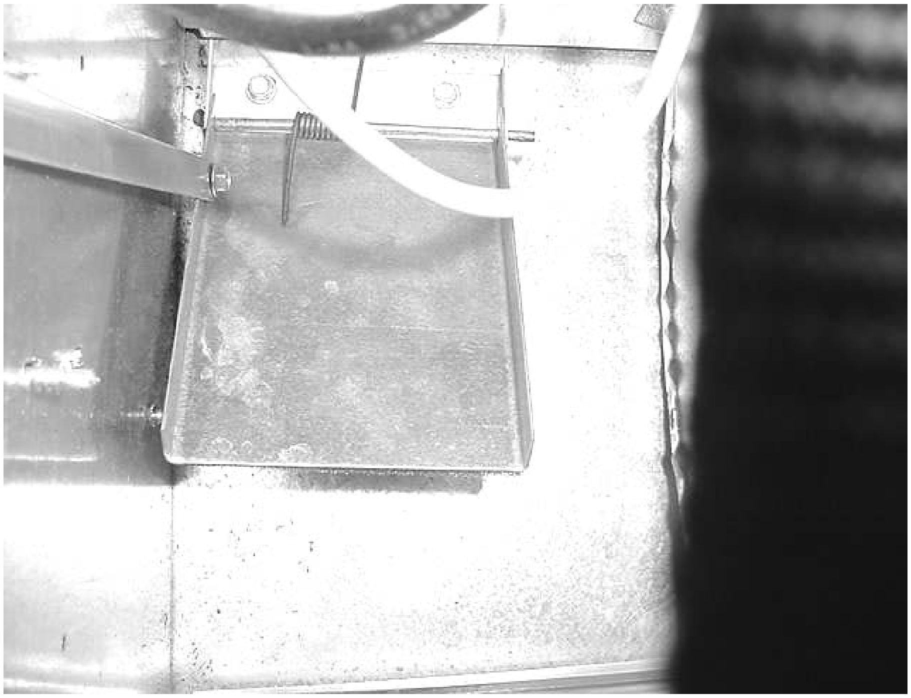
Picture 2

Univent

Picture 3

Small Handset Louver in Rear Of Univent

Picture 4



Univent Louver Set in The Open Position

Picture 5

Roof Top Exhaust Fans, Note Standing Water

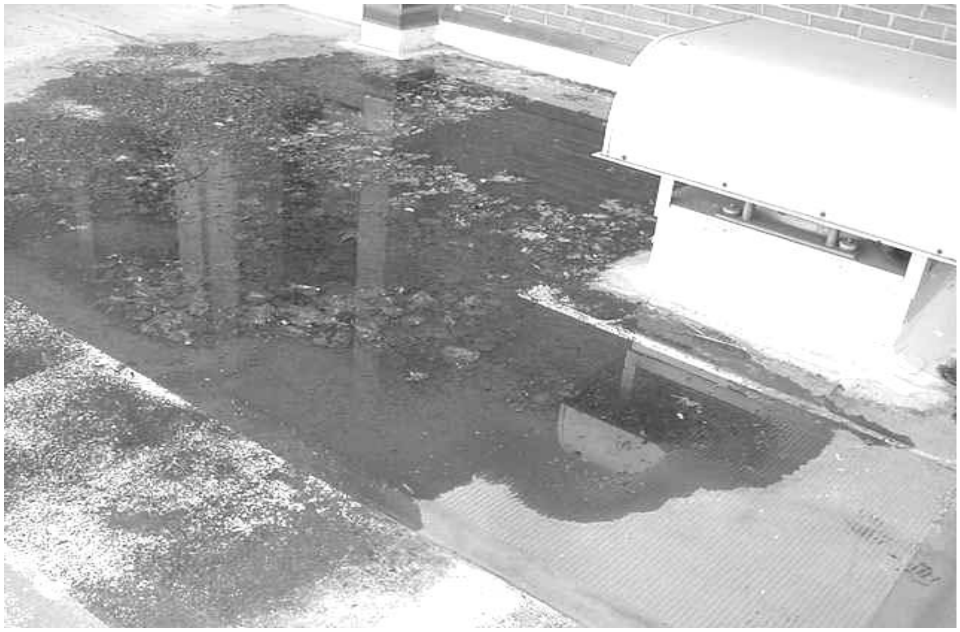
Picture 6

Exhaust Vents on Ceiling Of Atrium

Picture 7

Wall-Mounted Humidification Units

Picture 8



Debris on Roof, Note Pooling Water

Picture 9

Fiberglass Insulation on Roof

Picture 10

Plants Had Taken Root in The Debris and Were Growing on The Roof Membrane

Picture 11

Over watered Plant in Catalogue Area

Picture 12

Subterranean Pit That Serves as Fresh Air Intake, Note Leaves on Floor

Picture 13

Deactivated AHU Fan in the Lower Floor AHU

Picture 14

Condensation Drain for Lower Floor AHU, Note Accumulated Debris in Cup

TABLE 1

Indoor Air Test Results – Berkshire Athenaeum, Pittsfield MA. June 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	391	82	50					
Photocopy Room	553	76	50	0	Y	N	Y	FCU, exhaust vent blocked
Director Office	591	74	49	0	Y	Y	Y	Exhaust-no draw, exposed fiberglass
Cataloging	546	78	47	1	Y	Y	Y	Exhaust-no draw, windows open
Book Mending	495	79	44	1	Y	Y	Y	
2nd Floor Stacks	533	77	45	0	N	Y	Y	
Circulation	519	75	47	9	N	Y	Y	
Circulation Office	559	76	51	2	N	Y	Y	2 CT – from AHU 2nd floor
Reading Room	505	75	47	10	N	Y	Y	
Young Adult	518		48	2	N	Y	Y	Humidifier
Newspapers	516	76	47	3	N	Y	Y	

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Berkshire Athenaeum, Pittsfield MA. June 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Men's Room					N		Y	Exhaust off, dry trap?
Woman's Room					N		Y	Exhaust off, dry trap?
Reference	525	76	49	3	N	Y	Y	
Non Fiction	541	77	48	0	N	Y	Y	
Magazines	544	77	48	4	N	Y	Y	
Microfilm	501	79	52	3	N	Y	Y	
Allen Room	518	80	50	1	N	Y	Y	
Local History	464	81	52	3	N	Y	Y	
Melville Room	483	82	49	0	N	Y	Y	
Vault Local History	470	82	52	0				
Children's Front Desk	592	80	43	4	N	Y	Y	

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CT = ceiling tiles

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TABLE 3

Indoor Air Test Results – Berkshire Athenaeum, Pittsfield MA. June 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	

*** ppm = parts per million parts of air**
CT = ceiling tiles

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